SEE Test Report
Single event effects testing of the Texas Instruments Commercial CSD16403Q5A Power nMOSFET

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I. Introduction and Summary of Test Results

This study was undertaken to determine the single event gate rupture (SEGR) and burnout (SEB) susceptibility of the commercial CSD16403QA power MOSFET. Heavy-ion testing was conducted at the Texas A&M University Cyclotron Single Event Effects Test Facility (TAMU). Its purpose was two-fold: To evaluate these devices as candidates for use in NASA flight projects; and, to provide Texas Instruments independent test results on the SEGR/SEB hardness of these devices.

All failures during these tests were due to SEB. All tests were conducted at normal beam incidence in air. A summary of the minimum last pass/first fail drain-source voltage (Vds) for a given gate-source voltage bias (Vgs) is provided in Table I below as a function of the ion species, as well as energy, range, and LET at the surface of the device under test (DUT). The total number of devices tested under each beam and bias condition is shown in the final column. These data are plotted in Figure 1.

Table I: Summary of heavy-ion test results. All failures are due to SEB.

Ion Species	Surface-Incident Energy (MeV)	Range (um)	Surface-Incident LET (MeV.cm^2/mg)	Vgs (V)	Minimum Last Passing Vds (V)	Minimum Vds at Failure (V)	# of Devices Tested
Kr	1070	140	27.4	0	12	14	3
				-5	13	14	3
				-7	13	14	3
Ag	1348	125.3	41.5	0	13	14	3
				-7	13	14	3

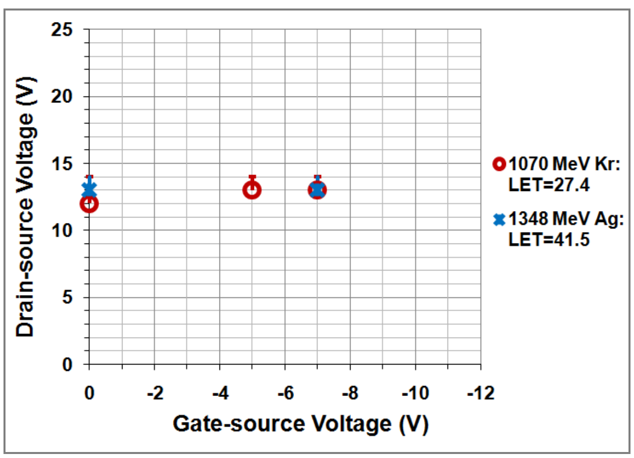

Figure 1. SEE response curve.

II. Devices Tested

The sample size for the testing was 18 pieces. These pieces were manufactured by Texas Instruments and delivered on 9/21/2009 in QFN 5mm x 6mm plastic packaging. Package markings included the part number: CSD16403; the Date Code: 0916C (16th work week of 2009, country of origin = China); and the wafer lot: 6W.08.

The commercial CSD16403Q5A is a 100 amp, 25 volt n-channel power MOSFET, manufactured under Texas Instruments' newly acquired CICLON NexFET™ commercial process technology. The NexFET technology is a hybrid lateral-vertical power MOSFET (figure 2) featuring a lateral channel under a planar gate connecting the source to the lightly doped drain extension region (LDD), and a highly doped vertical drain "sinker" that brings the current flow vertically down to the backside drain contact. Vendor electrical parameter specifications are given in Appendix A.

The pieces were delidded with an acid etch by Timothy Irwin, MEI Technologies, and surface mounted on custom PC boards by Timothy Irwin and/or Anthony Phan, MEI Technologies. Finally, each sample was electrically characterized both at GSFC and on-site at TAMU by Anthony Phan. The die measures approximately 0.358 cm by 0.381 cm, giving a die area of 0.136 cm^2. It is notable that the thick source bonding wires cross over the surface of the die, occluding close to ½ the die surface.

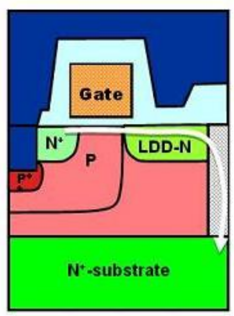

Figure 2. Cartoon showing the structure of a n-type NexFET™ power MOSFET. *From: Electronics Design, Strategy, News, 12 Feb 2009.*

III. Test Facility

Facility: Texas A&M University Cyclotron Single Event Effects Test Facility, 15 MeV/amu tune.
Flux: 1 x 10^3 particles/cm^2/s to 2.5 x 10^3 particles/cm^2/s.
Fluence: All tests were run to the lesser of 1 x 10^5 p/cm^2 or until destructive events occurred.
Ion species: Kr, Ag. The table below shows the surface-incident beam properties calculated using TAMU SEUSS (based upon SRIM 1995).

Ion	surface LET (MeV•cm^2/mg) [air gap (cm)]	Surface Energy (MeV)	Range (µm in Si)
^{84}Kr	27.4 [2]	1070	140
^{109}Ag	41.5 [2]	1348	125.3

IV. Test Setup

The test circuit, as shown in Figure 3, for the power MOSFET contains a Keithley 2400 source meter to provide the gate voltage (set to 0V, -5V, or -7V during irradiation) while measuring the gate current. A filter was placed at the gate node of each device under test (DUT) to dampen noise at the gate. A second Keithley 2400 source meter provided the appropriate Vdd while measuring the drain current. Gate current was limited to 1mA, and drain current limited to 1.0A, and recorded via GPIB card to a desktop computer at approximately 150 ms intervals.

A differential probe across the 1.0 Ω drain sense resistor fed into a digital oscilloscope that was set to trigger on current transients of a predetermined size, saving them to file. Nine devices at a time were mounted on the test board and individually accessed via a switch box within the control room. The terminals of the devices not under test were then shorted to ground. A PST-3202 power supply controlled mechanical switches located on test board in order to switch the oscilloscope probe to the appropriate DUT. The DUT was placed 2.0 cm from the beam aperture and centered within the 1 inch beam diameter. All ion exposures were conducted at normal angle of incidence to the DUT surface. Figure 4 shows photos of the test board and test equipment as set up at TAMU.

The test setup was controlled via custom LabView codes written by Hak Kim for this test. One program controls the source measuring units (SMUs), gate current limit, oscilloscope monitoring and transient capture, and gate and drain current sampling and recording. The second LabView code is designed to perform a parametric analysis of each DUT prior to irradiation, recording Ig as a function of Vgs, Id as a function of Vgs, gate threshold voltage (Vth), drain-source breakdown voltage (BVdss), and zero gate voltage drain current (Idss). In addition, the code conducts a post-irradiation gate stress (PIGS) test after each run to test the integrity of the gate dielectric and measure the gate leakage current. The 100Ω isolation resistor was removed from the circuit by mechanical switch during electrical characterization tests.

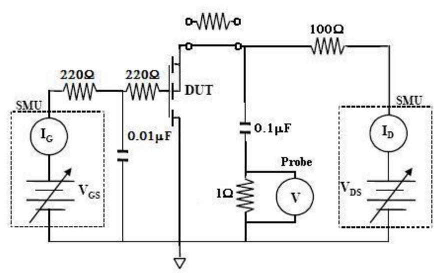

Figure 3. Test setup for the commercial CSD16403Q5A power MOSFET.

Table II. Test equipment.

Node	Make/model	s/n
Gate	Keithley 2400 source meter	(REAG S/N 1)
Drain	Keithley 2400 source meter Tektronix DPO4054 Differential probe GW Instek PST-3202 Programmable power supply	(REAG S/N 3) B020036
Other	2 Lenova IBM ThinkCentre desktop computers Power Conditioner Switchbox (custom design)	

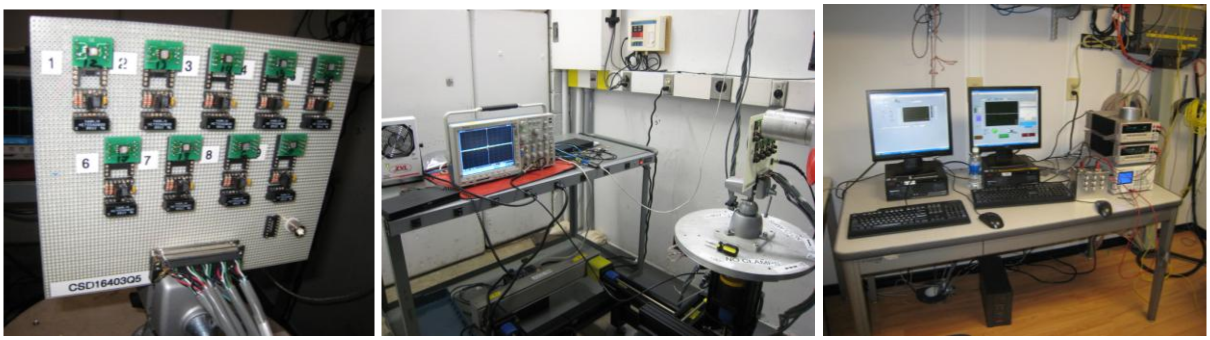

Figure 4. Left: Test board with 9 individually-selectable DUTs mounted. Middle: Board positioned in front of the beam, with oscilloscope nearby. Right: Operator control room with sourcing-and-measurement units, computer interfaces, and switchbox.

V. Test Results

Tests were performed at Texas A&M University Cyclotron Single Event Effects Test Facility on December 8-9, 2009. Two different monoenergetic ion beams (1070 MeV krypton, and 1348 MeV silver) were used; all tests were conducted with the beam at normal angle of incidence to the DUT. Following each run, a post-irradiation gate stress (PIGS) test was performed in which the gate current was measured while the gate voltage was swept from 0V to 16V, then from 0V to -12V, at 0Vds. All device failures occurred during irradiation and were due to single event burnout, although in each instance the gate ruptured secondarily. The maximum gate current source limit was set at 1mA. Pretest electrical characterization results are in Appendix B. Table III summarizes the heavy-ion test results for each DUT. Complete results are in Appendix C.

Table III. Summary of bias conditions at device failure. Beam attributes are DUT surface-incident values.

Ion Specie	Energy (MeV)	Range (um)	LET ($MeV.cm^2$/mg)	DUT #	Vgs (V)	Last Passing Vds (V)	First Failing Vds (V)	Comments
Kr	1070	140	27.4	1	0	12	14	
				2	0	12	14	
				3	0	14	16	
				4	-5	14	15	
				5	-5	13	14	
				7	-5	14	15	
				8	-7	14	15	
				11	-7	12	14	
				10	-7	13	14	
				12	-7	13	14	26 Ω on drain node
Ag	1348	41.5	125.3	14	0	13	14	
				15	0	13	14	
				16	0	13	14	
				17	-7	13	14	
				6	-7	13	14	
				9	-7	14	15	
				18	0	13	14	100 Ω on drain node
				13	0	14	15	1 kΩ on drain node

As can be seen in Figure 1 in the first section of this report, the SEE safe operating area is 52% of the maximum rated drain voltage, independent of the gate bias applied during testing. This gate-voltage independence is a hallmark of single-event burnout. In addition, both krypton at an incident LET of 27.4 MeV-cm^2/mg and silver at an incident LET of 40.5 MeV-cm^2/mg yielded the same SEE response curves. Dodd, *et al.*[1] report a LET saturation effect for SEB in a lateral power MOSFET, such that there is a certain LET above which the SEB threshold no longer decreases.

The CSD16403Q5A is part of a commercial process; as such, it is not specifically designed for total dose hardness. During the heavy-ion beam exposures reported here, samples experienced shifts in the gate threshold voltage despite the low levels of accumulated dose during the tests. However, for all DUTs, the gate threshold voltage degraded but did not fall out of specification prior to SEB. Figure 5 shows the change in threshold voltage as a function of either krypton or silver dose, for a selection of DUTs. This threshold gate voltage degradation at very low heavy-ion doses suggests that for missions accumulating dose primarily from protons, TID hardness would be more accurately evaluated with proton irradiation instead of gamma rays.

As can be seen in the plot in figure 5, dose from the heavier ion species (silver) had a stronger effect on the gate threshold voltage. In addition, more negative gate voltage during irradiation resulted in greater threshold degradation regardless of ion species. Large gate voltages rapidly separate ionized charge, resulting in greater hole trapping in the oxide. Positive gate biases would be expected to yield even stronger dose effects for these devices due to charge separation in a field favouring hole migration toward the Si-SiO_2 interface where they have their strongest influence on the n-channel threshold voltage.

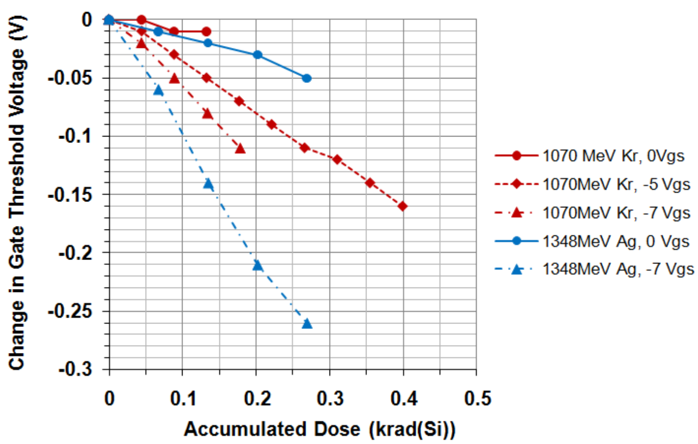

Figure 5. Degradation of the gate threshold voltage as a function of heavy-ion dose, species, and gate bias during irradiation. Curves are of data from individual DUTs.

[1] P. E. Dodd, M. R. Shaneyfelt, B. L. Draper, R. W. Young, D. Savignon, J. B. Witcher, G. Vizkelethy, J. R. Schwank, Z. J. Shen, P. Shea, M. Landowski, and S. M. Dalton, "Development of a Radiation-Hardened Lateral Power MOSFET for POL Applications," *Nuclear Science, IEEE Transactions on,* vol. 56, pp. 3456-3462, 2009.

Appendix A

Table A1. Commercial CSD16403Q5A vendor-specified electrical parameters (partial list).

Parameter	Condition	MIN	MAX	Units
Gate Threshold Voltage (VGSth)	Vds = Vgs, Id = 250 uA	1.2	1.9	V
Zero Gate Voltage Drain Current (Idss)	Vds = 20V, Vgs = 0V		1	uA
Drain-Source Breakdown Voltage (BVdss)	Vgs = 0V, Id = 250uA	25		V
Gate-Source Leakage Current (Igss)	Vgs = +16V/-12V, Vds = 0V		+/- 100	nA
Static Drain-Source Resistance (Rds_on)	Vgs = 4.5V, Id = 20A Vgs = 10V, Id = 20A		3.7 2.8	mΩ
Forward Voltage (Vsd)	Is = 20A, Vgs = 0V		1	V

Appendix B

Table B1. Pretest electrical characterization.

Part SN	Vth	BVdss	Idss	Igss +/-
	(Volts)	(Volts)	(nA)	(nA)
1	1.54	>25	-1.78	17.9/-5.2
2	1.61	>25	18.2	16.7/-9.5
3	1.56	>25	-2.76	13.0/-2.4
4	1.54	>25	2.52	1.0/-0.8
5	1.54	>25	3.34	0.9/-0.9
6	1.58	>25	62.49	76.4/-69.9
7	1.62	>25	178.81	20.5/-14.9
8	1.56	>25	2.83	1.1/-0.9
9	1.62	>25	458.79	11.6/-8.7
10	1.54	>25	0.92	0.8/-0.9
11	1.57	>25	-2.03	0.8/-0.9
12	1.59	>25	8.22	1.3/-1.6
13*	1.60	>25	36.05	1.3/-1.2
14	1.53	>25	-2.77	1.1/-1.0
15	1.60	>25	6.45	0.8/-0.7
16	1.57	>25	-1.92	0.8/-0.9
17	1.56	>25	-1.48	0.8/-0.8
18**	1.53	>25	-0.18	1.0/-0.9

*1 kΩ resistor on drain node.

** 100 Ω resistor on drain node.

Appendix C

Table C1. Raw test data from 8-9 December 2009. Beam diameter = 1"; LET, energy, and range are at the Si epilayer surface, as calculated by TAMU SEUSS (based upon SRIM 1995). See test report section III for values incident upon the die surface.

Run Date	Time	Run #	Ion	LET *MeV.cm2/mg*	Energy *MeV/amu*	Energy *MeV*	Range *μm*	Ave. Flux *#/cm2/sec*	Fluence *#/cm2*	Dose *rad (Si)*	Cum. *Dose*	S/N	Socket *#*	VGS *V*	VDS *V*	Vth *V*	Idss *nA*	Pass/ Fail	Comments
12/8/09	18:00	1	Kr	27.7	12.4	1041	135.4	2.55E+03	5.290E+05	2.35E+02	2.35E+02	1	1	0	10	1.51	-2.76		
	18:09	2	Kr	27.7	12.4	1041	135.4	2.65E+03	9.899E+04	4.40E+01	2.79E+02	1	1	0	12	1.51	-2.27		
	18:15	3	Kr	27.7	12.4	1041	135.4	2.51E+03	3.35E+04	1.49E+01	2.94E+02	1	1	0	14			Fail	
	18:27	4	Kr	27.7	12.4	1041	135.4	2.24E+03	1.00E+05	4.45E+01	4.45E+01	2	2	0	10	1.61	12.31		
	18:31	5	Kr	27.7	12.4	1041	135.4	2.12E+03	1.01E+05	4.49E+01	8.94E+01	2	2	0	12	1.6	22.73		
	18:37	6	Kr	27.7	12.4	1041	135.4	2.34E+03	1.01E+05	4.48E+01	1.34E+02	2	2	0	14			Fail	
	18:45	7	Kr	27.7	12.4	1041	135.4	2.09E+03	9.90E+04	4.40E+01	4.40E+01	3	3	0	10	1.56	2.16		
	18:49	8	Kr	27.7	12.4	1041	135.4	2.00E+03	9.96E+04	4.43E+01	8.82E+01	3	3	0	12	1.55	-2.35		
	18:54	9	Kr	27.7	12.4	1041	135.4	1.89E+03	9.95E+04	4.42E+01	1.32E+02	3	3	0	14	1.55	-0.333		
	19:03	10	Kr	27.7	12.4	1041	135.4	1.57E+03	4.51E+03	2.01E+00	1.34E+02	3	3	0	16			Fail	
	19:11	11	Kr	27.7	12.4	1041	135.4	1.81E+03	1.01E+05	4.48E+01	4.48E+01	4	4	-5	5	1.53	-0.187		
	19:17	12	Kr	27.7	12.4	1041	135.4	1.80E+03	9.93E+04	4.41E+01	8.89E+01	4	4	-5	7	1.51	0.528		
	19:22	13	Kr	27.7	12.4	1041	135.4	1.59E+03	9.93E+04	4.41E+01	1.33E+02	4	4	-5	8	1.49	-0.547		
	19:27	14	Kr	27.7	12.4	1041	135.4	1.71E+03	9.99E+04	4.44E+01	1.77E+02	4	4	-5	9	1.47	-1.2		
	19:32	15	Kr	27.7	12.4	1041	135.4	1.64E+03	9.92E+04	4.41E+01	2.21E+02	4	4	-5	10	1.45	3.60		
	19:37	16	Kr	27.7	12.4	1041	135.4	1.61E+03	1.01E+05	4.48E+01	2.66E+02	4	4	-5	11	1.43	0.415		
	19:42	17	Kr	27.7	12.4	1041	135.4	1.70E+03	1.00E+05	4.45E+01	3.11E+02	4	4	-5	12	1.42	-3.18		
	19:47	18	Kr	27.7	12.4	1041	135.4	1.46E+03	1.00E+05	4.44E+01	3.55E+02	4	4	-5	13	1.4	-2.27		
	19:52	19	Kr	27.7	12.4	1041	135.4	1.48E+03	9.98E+04	4.43E+01	4.00E+02	4	4	-5	14	1.38	0.089		
	19:57	20	Kr	27.7	12.4	1041	135.4	1.01E+03	3.55E+03	1.58E+00	4.01E+02	4	4	-5	15			Fail	
	20:05	21	Kr	27.7	12.4	1041	135.4	2.33E+03	9.97E+04	4.43E+01	4.43E+01	5	5	-5	10	1.52	2.52		
	20:10	22	Kr	27.7	12.4	1041	135.4	2.36E+03	9.93E+04	4.41E+01	8.84E+01	5	5	-5	11	1.49	-3.12		
	20:14	23	Kr	27.7	12.4	1041	135.4	2.38E+03	1.00E+05	4.45E+01	1.33E+02	5	5	-5	12	1.47	3.08		
	20:19	24	Kr	27.7	12.4	1041	135.4	2.27E+03	1.01E+05	4.48E+01	1.78E+02	5	5	-5	13	1.45	3.88		
	20:23	25	Kr	27.7	12.4	1041	135.4	2.32E+03	6.36E+04	2.83E+01	2.06E+02	5	5	-5	14			Fail	
	20:33	26	Kr	27.7	12.4	1041	135.4	2.29E+03	1.01E+05	4.48E+01	4.48E+01	7	7	-5	12	1.6	65.45		

Run Date	Time	Run #	Ion	LET MeV.cm2/mg	Energy MeV/amu	Energy MeV	Range μm	Ave. Flux #/cm2/sec	Fluence #/cm2	Dose rad (Si)	Cum. Dose	S/N	Socket #	VGS V	VDS V	Vth V	Idss nA	Pass/ Fail	Comments
	20:37	27	Kr	27.7	12.4	1041	135.4	2.32E+03	9.92E+04	4.41E+01	8.88E+01	7	7	-5	13	1.58	351.5		
	21:44	28	Kr	27.7	12.4	1041	135.4	1.79E+03	9.92E+04	4.41E+01	1.33E+02	7	7	-5	14	1.55	201,580		(Pre run Idss was ~179nA)
	21:50	29	Kr	27.7	12.4	1041	135.4	1.30E+03	3.15E+03	1.40E+00	1.34E+02	7	7	-5	15			Fail	
	21:56	30	Kr	27.7	12.4	1041	135.4	1.42E+03	9.96E+04	4.42E+01	4.42E+01	8	8	-7	8	1.54	4.47		
	22:00	31	Kr	27.7	12.4	1041	135.4	1.64E+03	1.01E+05	4.47E+01	8.89E+01	8	8	-7	10	1.51	3.33		
	22:03	32	Kr	27.7	12.4	1041	135.4	1.67E+03	1.01E+05	4.48E+01	1.34E+02	8	8	-7	12	1.48	6.19		
	22:07	33	Kr	27.7	12.4	1041	135.4	1.58E+03	1.00E+05	4.44E+01	1.78E+02	8	8	-7	14	1.45	6.93		
	22:10	34	Kr	27.7	12.4	1041	135.4	1.24E+03	5.11E+03	2.27E+00	1.80E+02	8	8	-7	15			Fail	
	22:33	35	Kr	27.7	12.4	1041	135.4	1.18E+03	1.01E+05	4.47E+01	4.47E+01	11	9	-7	12	1.54	3.03		
	22:37	36	Kr	27.7	12.4	1041	135.4	1.20E+03	9.42E+03	4.18E+01	4.18E+01	11	9	-7	14			Fail	
	22:45	37	Kr	27.7	12.4	1041	135.4	1.18E+03	1.00E+05	4.45E+01	4.45E+01	10	6	-7	12	1.51	-0.695		
	22:51	38	Kr	27.7	12.4	1041	135.4	1.14E+03	1.00E+05	4.44E+01	8.89E+01	10	6	-7	13	1.48	4.11		
	23:02	39	Kr	27.7	12.4	1041	135.4	1.28E+03	8.70E+03	3.86E+00	9.28E+01	10	6	-7	14			Fail	
12/9/09	1:40	40	Kr	27.7	12.4	1041	135.4	1.09E+03	1.00E+05	4.45E+01	4.45E+01	12	1	-7	12	1.56	7.61		with 26ohm R on drain node
	1:46	41	Kr	27.7	12.4	1041	135.4	1.30E+03	1.01E+05	4.46E+01	8.91E+01	12	1	-7	13	1.52	15.85		
	1:54	42	Kr	27.7	12.4	1041	135.4	1.25E+03	4.87E+04	2.16E+01	1.11E+02	12	1	-7	14			Fail	
	2:38	43	Ag	42	12	1303	120.7	9.80E+02	9.98E+04	6.71E+01	6.71E+01	14	3	0	8	1.53	-0.964		DUT 12 still in beam
	2:44	44	Ag	42	12	1303	120.7	1.20E+03	9.96E+04	6.70E+01	1.34E+02	14	3	0	10	1.53	-2.35		DUT 12 still in beam
	2:51	45	Ag	42	12	1303	120.7	1.26E+03	9.98E+04	6.72E+01	6.72E+01	14	3	0	8	1.52	-0.8252		
	2:55	46	Ag	42	12	1303	120.7	1.29E+03	1.01E+05	6.76E+01	1.35E+02	14	3	0	10	1.51	-3.74		
	3:00	47	Ag	42	12	1303	120.7	1.39E+03	9.97E+04	6.71E+01	2.02E+02	14	3	0	12	1.5	-4.26		
	3:05	48	Ag	42	12	1303	120.7	1.56E+03	9.96E+04	6.70E+01	2.69E+02	14	3	0	13	1.48	-5.01		
	3:11	49	Ag	42	12	1303	120.7	1.55E+03	9.14E+03	6.15E+00	2.75E+02	14	3	0	14			Fail	
	3:19	50	Ag	42	12	1303	120.7	1.32E+03	9.99E+04	6.72E+01	6.72E+01	15	4	0	12	1.59	-1.76		
	3:24	51	Ag	42	12	1303	120.7	1.40E+03	9.94E+04	6.69E+01	1.34E+02	15	4	0	13	1.58	-2.45		
	3:28	52	Ag	42	12	1303	120.7	1.64E+03	4.81E+04	3.24E+01	1.67E+02	15	4	0	14			Fail	
	3:35	53	Ag	42	12	1303	120.7	2.01E+03	1.01E+05	6.79E+01	6.79E+01	16	5	0	12	1.55	1.09		
	3:39	54	Ag	42	12	1303	120.7	2.14E+03	1.00E+05	6.73E+01	1.35E+02	16	5	0	13	1.54	-3.91		
	3:42	55	Ag	42	12	1303	120.7	1.92E+03	7.30E+03	4.91E+00	1.40E+02	16	5	0	14			Fail	
	3:54	56	Ag	42	12	1303	120.7	1.47E+03	1.00E+05	6.76E+01	6.76E+01	17	6	-7	8	1.5	8.46		

Run Date	Time	Run #	Ion	LET MeV.cm2/mg	Energy MeV/amu	Energy MeV	Range µm	Ave. Flux #/cm2/sec	Fluence #/cm2	Dose rad (Si)	Cum. Dose	S/N	Socket #	VGS V	VDS V	Vth V	Idss nA	Pass/ Fail	Comments
	3:59	57	Ag	42	12	1303	120.7	1.38E+03	1.01E+05	6.78E+01	1.35E+02	17	6	-7	10	1.42	12.19		
	4:03	58	Ag	42	12	1303	120.7	1.34E+03	9.94E+04	6.69E+01	2.02E+02	17	6	-7	12	1.35	29.55		
	4:08	59	Ag	42	12	1303	120.7	1.30E+03	9.97E+04	6.71E+01	2.69E+02	17	6	-7	13	1.3	40.38		
	4:13	60	Ag	42	12	1303	120.7	1.26E+03	2.32E+04	1.84E+01	2.88E+02	17	6	-7	14			Fail	
	4:22	61	Ag	42	12	1303	120.7	1.14E+03	1.00E+05	6.74E+01	6.74E+01	6	8	-7	13	1.5	93.57		
	4:28	62	Ag	42	12	1303	120.7	1.05E+03	4.43E+03	2.98E+00	7.04E+01	6	8	-7	14			Fail	
	4:39	63	Ag	42	12	1303	120.7	1.07E+03	1.00E+05	6.74E+01	6.74E+01	9	9	-7	13	1.58	325.26		
	4:44	64	Ag	42	12	1303	120.7	1.20E+03	1.00E+05	6.75E+01	1.35E+02	9	9	-7	14	1.53	245.74		
	4:48	65	Ag	42	12	1303	120.7	1.00E+03	5.59E+03	3.76E+00	1.39E+02	9	9	-7	15			Fail	
	5:15	66	Ag	42	12	1303	120.7	8.19E+02	9.98E+04	6.71E+01	6.71E+01	18	1	0	12	1.52	1.43		100ohm R on drain node
	5:20	67	Ag	42	12	1303	120.7	1.69E+03	9.99E+04	6.72E+01	1.34E+02	18	1	0	13	1.51	0.778		
	5:23	68	Ag	42	12	1303	120.7	1.79E+03	1.97E+04	1.33E+01	1.48E+02	18	1	0	14			Fail	
	5:45	69	Ag	42	12	1303	120.7	1.19E+03	9.97E+04	6.71E+01	6.71E+01	13	2	0	13	1.59	34.51		1kohm R on drain node
	5:49	70	Ag	42	12	1303	120.7	1.16E+03	9.96E+04	6.70E+01	1.34E+02	13	2	0	14	1.57	21.19		Lots of transients
	5:53	71	Ag	42	12	1303	120.7	1.02E+03	1.12E+04	7.53E+00	1.42E+02	13	2	0	15			Fail	